THE ENGINEERING PROFESSION FIFTY YEARS HENCE. III

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Promotion of Projects

Americans for two centuries have been notorious as promoters of projects. For this habit they have often been adversely criticized; but it should not be forgotten that, were it not for the enterprise, zeal, and courage of such men, our country would not be standing to-day as the acknowledged leader of the world. It is true that promotions used often to be carried to extremes, and that wild-cat schemes were only too common. The almost irrepressible enthusiasm of Americans needed a curb, and it certainly got it soon after the academy appointed a standing committee to pass upon all projects submitted to it involving the expenditure of more than a quarter of a million dollars. Bankers soon dropped into the habit of refusing to consider any large project that did not have the endorsement of the academy. The investigation of the soundness of any project is not done directly by the committee but by an engineer, or a firm of engineers, chosen by the said committee and paid a standard fee by the promoter. No real hardship for the latter is involved by this arrangement, because he is not actually compelled to come to the academy for an endorsement, although, truth to tell, the number of promoters is far smaller to-day than it used to be formerly. On the other hand, a far greater proportion of the schemes submitted to capitalists is materialized.

Working Abroad

Until the beginning of the third decade of the century, American financiers and business men were so interested in the development of our own country that they neglected the fine opportunities which constantly presented themselves for securing work abroad, especially in Latin America, although there was no dearth of American engineers who were eager to go to such countries in the service of any sound corporation. Some of them were willing to do more, for, having the "roving spirit" in their blood, they went as soldiers of fortune to Mexico, Cuba, and many of the South American republics. A

few of them made good, but the large majority sooner or later came to grief for one cause or another. It was, as once before stated, the Great War that opened the eyes of Americans to the business opportunities in the countries to the south. At first the failure of our young men to understand Spanish militated greatly against progress in business with the Latin Americans; but a wave of enthusiasm for the study of that language suddenly overtook the country, and soon thereafter a large number of young American men and women possessed a good working knowledge of *la lengua castellana;* and their services were in immediate demand at good salaries.

There existed up to the end of the second decade a condition which acted adversely and seriously against the establishment on a large scale of business relations with foreign countries, viz., the apathy of the American government in protecting the rights of its citizens outside the boundaries of the United States. When Mr. William Jennings Bryan was Secretary of State, he made it plain to our soldiers of fortune and to our financial men that if they invested their money abroad it would be at their own risk, and that they need not look to the United States government for protection, in case of being defrauded of their foreign holdings by any illegal or piratical act of another nation. Such a pusillanimous doctrine was a disgrace to our country! Fortunately, the war taught the Administration the fallacy of it, and brought on a change of heart, with the result that now there is no nation in the world whose citizens are as well treated in foreign countries as are ours. It took years and much effort to accomplish this desideratum; but the result is worth incomparably more than all of the labor involved.

In the development of business relations with all foreign countries our academy has played a leading part, in that through its honorary members, who are always chosen from the most prominent and active engineers abroad, it receives annually therefrom reports concerning the progress of all kinds of engineering works during the past year. Besides, these honorary members have often interested themselves in promoting closer business relations between their countrymen and ours.

Publicity Movements

The publicity movement started by the Cleveland Engineering Society a little over fifty years ago, with the double object of bringing local engineers into touch with their fellow townsmen, and of making the latter conversant in an interesting way with the most important of the current feats of engineering,

was gradually taken up by the local technical societies of other cities, until in time our profession became well and favorably known to the general public throughout the country. This movement was and still is fostered and encouraged by our academy through its specially friendly relations with the engineers' clubs and local technical societies which are now to be found in all American cities of any size.

Public Recognition

As the education of engineers became broader, they took more interest than formerly in local, state, and national politics; and because of their superior mental attainments, people soon began to select them as their representatives, at first as mayors and city managers, then as state legislators and governors, and then as U. S. congressmen and senators. Finally, in 1932, a civil engineer was elected president of the United States, thus making our country follow the example set by Cuba in 1912, when it elected General Menocal, a civil engineer of high standing, to the presidency of that republic. Since 1932 two other engineers have occupied the presidential chair at the White House.

Public recognition is truly the main object of engineering endeavor, because engineers more than any other class of people place honor and glory above the "almighty dollar," although it can not be denied that the accumulation of a reasonable amount of wealth is a proper ambition for any technical man.

This brings to a close my observations concerning the main causes of the wonderful advancement of the engineering profession during the last half-century; and now I shall proceed to indicate the most striking improvements which have been effected during that period in the various lines of engineering activity, taking them up in alphabetical order so as to avoid all possibility of criticism for alleged partiality.

Aeronautics

While the flying machine was made a *fait accompli* only in 1907, its perfection into a serviceable means of transportation was hastened by the Great War and by the silent preparation therefor on the part of some of the contestants. As a fighting machine it then reached the acme of perfection, because there has been no real war subsequently; but as a means of transportation for the business of peace it has since been wonderfully improved, and its carrying capacity has been augmented fully twenty-fold. There are now regular lines of passenger airships flying between the principal cities of the North American con-

tinent, and a considerable amount of first-class mail and a smaller amount of light express matter travel in the same manner; but it has not proved economical to transport freight through the air.

So great is the air-travel that it has been found necessary to pass stringent laws confining planes going to and from certain places and in certain directions to limited spaces, in order to avoid collisions. However, it has very seldom been found feasible to punish offenders for the infraction of these laws, because, if they escape collision, it is difficult to establish proof of the offense, while if they do not, it is generally unnecessary to penalize them.

Nearly fifty years ago the first flight to Europe was accomplished; and since then some desultory flying across the ocean has been practisced, but nothing of the kind on a commercial scale has yet been effected, in spite of repeated trials. Many of the hitherto inaccessible places of the world, such as mountain-tops and the lands of perpetual snow and ice, have been reached by the airplane; but such trips are fraught with so much peril that they have not become popular. Practically all of them have been made in the interests of science and exploration, only a few of them having proved remunerative through the discovery of deposits of certain rare minerals of value in the arts. The development and perfecting of the helicopter have enabled airplanes to alight with almost no shock in small spaces and to rise vertically from the ground. All the high mountains of the world have been sailed over by the airplane, consequently there is now no place on the earth which has not been visited by man. One of the most useful fields of the aeroplane is in making reconnaissances and preliminary surveys for railroads, continuous photographs of the country being taken, and the mapping thereof being done automatically—of course, in a rather crude manner, but with sufficient accuracy for exploratory work.

Agricultural Engineering

Agriculture as practised in America during the nineteenth century was exceedingly extravagant and crude. Very little scientific study was given to the subject until the state universities about 1900 began methodically to teach agriculture. The universities of the middle west were the first institutions to take hold of the matter in real earnest; and it was an acknowledged fact that the University of Wisconsin doubled the agricultural product of the state in a very few years simply by teaching its farmers the rudiments of scientific farming.

The shortage of food for the entire world during the Great War brought home to the American people the realization of the necessity for more thorough and economic methods of cultivating their soil. About all that could be done during the struggle was to increase the acreage of the crops and work longer hours, with the result that a material enlargement of the output was effected. Some attention, too, was then given to richer fertilization, but it was not until after peace had been declared that a systematic study was made of the problem of really multiplying materially the outputs of the various products of the soil in the different parts of the country. Commissions were sent to China, Japan, India, Holland, Belgium, and some other countries to study intensive farming; the best rotation of crops for the different soils was determined; economic fertilization was thoroughly investigated; the destruction of insect and animal pests was studied and put into practise; the utilization of all farm produce was established so firmly that the waste of anything at all usable soon came to be considered almost a crime; the breeding of domestic animals was reduced to a science; the employment of power instead of human labor, wherever possible, became widespread; the proper housing and care of machinery and tools was made compulsory by law; effective protection against fire and flood was instituted; all the really necessary conveniences and comforts of city life were brought to the farmers' houses; the roads were so improved as to reduce to a minimum the cost of hauling produce to market; and the life of the farmer and his family was made so attractive as to call to the soil the overplus of population which used to render our great cities so unhealthful and make urban life such a burden to the poor.

The production on a large scale of nitrates from the atmosphere, now a government monopoly, has done much to prevent the exhaustion of the soil. The taking over of this industry by the government was a natural sequence of its control of the manufacture and distribution of power, concerning which I have previously spoken at length. All excess power, or that which is not required for other purposes, is employed for nitrate production; and in seasons of flood the hydro-electric-power plants manufacture and store immense supplies of that material.

Applied Chemistry

As indicated previously, the Great War started such a boom of activity in chemical engineering as to make America subsequently independent of Europe not only for all the necessities

but also for many of the luxuries of modern life, as well as for war supplies of every description, in case such should ever again be needed. New departments in our universities and technical schools for chemical engineering soon sprang into existence; and that branch of the profession quickly became one of the most popular and lucrative of them all, and has so continued to be ever since. In the economic disposal of sewage and garbage, chemical engineering has played a leading part.

BRIDGES

Fifty years ago bridge building had truly been reduced to a science; for it had been more thoroughly investigated and written up than any other branch of engineering. For that reason there have not been made in the last half-century as many improvements in this specialty as there have been in most of the others. In 1917, one of the leading bridge engineers of those days stated that the near future would mark the end of long-span bridge-construction, because the increasing scarcity of structural materials and the consequent rise in their price would render their cost prohibitive. As a prophet, he proved an utter failure, because scores of long-span bridges have since been constructed, the longest span being about three thousand feet in the case of the North River Highway Bridge at New York City. His alarm over the growing dearth of structural materials proved to be groundless, because soon afterwards enormous deposits of both fuel and iron were discovered. They were not developed, however, for some years, because the old sources of supply were sufficient, and because expensive lines of transportation were required to reach many of the new deposits.

Time has shown that the demand for a large bridge at an important crossing increases with the development of the adjacent metropolitan communities. Not only is there a continual growth in the keen necessity for lines of transportation over the water, but there is also an accompanying and more than proportionate growth in the wealth of the communities affected. With such increasing wealth there is bound to come a time when the demand for a bridge will far outweigh the obstacle of expense. In other words, the capitalized economic value of the project will ultimately increase to a point where it will more than balance the cost of construction.

The main reason for the existence to-day of so many long-span bridges is the fact that we have at our disposal for their building a truly high alloy of steel. That such is the case is due

to the persistent efforts of my grandfather, extended over a period of two decades, in his search for an ideal alloy for long-span bridge building. His extensive experiments in the early twenties, using Mayarí steel as a basis, resulted in the obtaining of alloys having the following elastic limits:

For plate-and-shape steel, to be sub-punched and reamed, 65,000 pounds per square inch; for plate-and-shape steel, to be drilled solid, 75,000 pounds per square inch; and for eye-bar steel, heat-treated, 90,000 pounds per square inch. No material improvement in alloy bridge-steel has since been made, excepting only that it has been found practicable to manufacture heat-treated eye-bars having an elastic limit of 100,000 pounds per square inch.

The use of reinforced concrete for bridges has increased immensely in the past half-century. It is very seldom to-day that any span under 250 feet is built of steel; and reinforced-concrete arches of 350 feet span are not uncommon. A few longer ones have been built, one as long as 460 feet, but they are uneconomic on account of the great expense of erection and the numerous difficulties encountered in keeping the arch rings to proper elevation during construction.

In pier foundations no important advance has been made since the building of the great Mississippi River Bridge at New Orleans, where the piers were sunk 225 feet below low water, and had their bases enlarged by the injection of grouting. The pneumatic process of pier sinking has been somewhat improved, so that it is now comparatively safe for the workmen to operate under a head of 125 feet of water; and in a few cases pneumatic piers have been put down several feet deeper than this.

For certain new railroad lines with the widened gauge, the actual live loads have been increased to Class 85, which means axle-loadings of 85,000 pounds and carloads of 8,500 pounds per lineal foot; but for the standard-gauge railroads the old maximum of Class 70 still suffices, for the reason that it is as large a loading as the old-fashioned type of track will support.

In highway bridges there are no more wooden floors, even in country districts, because the auto-truck loads that are employed in all parts of North America are so great that it is unsafe to run them over any plank floor supported on timber joists. That type of floor system received vigorous adverse comment in the technical press in 1918, but it took a full decade to educate the public to an appreciation of its unfitness for carrying modern highway live loads.

CANALS

In no line of engineering in the United States has greater progress been made during the past fifty years than in that of canal building. Immediately after the conclusion of the Great War, work was started on the Bowen Canal, joining Lakes Erie and Ontario and running behind the city of Buffalo, so as to reverse the flow of all the streams and main sewers in that city. The object of the canal is three-fold, viz.: It is a ship canal that accommodates the largest-sized vessels on the Great Lakes; it withdraws the sewage of Buffalo and the neighboring towns from the Niagara River and thus permits the water of the latter to be safely utilized for drinking purposes; and it develops some 750,000 horse-power. Its two lift-locks, each consisting of a pair of balanced steel tanks, some 660 feet long, 70 feet wide in the clear, and 35 feet deep, to contain 30 feet of water, in one the rise being 208 feet and in the other 104 feet, were an innovation in canal building; and nothing like them in magnitude has since been constructed.

Following the completion of this immense work, a series of canals and deepened rivers was begun so as to make it practicable not only for all lake vessels to reach the ocean, but also for a large proportion of ocean-going vessels to pass to the Great Lakes and discharge and take on cargoes at all of the large cities situated thereon.

Simultaneously with these there was constructed by the federal government the Inter-Coastal Canal, extending from the city of Boston to the mouth of the Rio Grande, and continued from there by the Mexican government as far as Vera Cruz. Ultimately it may be extended still farther.

Early in the forties our government undertook the construction of another interoceanic canal, adopting therefor the old Nicaragua route. It required nearly ten years to complete the work of construction.

Again, it was found economical to build on an enlarged scale many barge canals in various parts of the country, so as to lessen the cost of hauling produce, including the Great North-and-South Canal, which extends from the Canadian border to the Gulf of Mexico.

HEATING

The development of central heating-plants in cities and large towns which took place during the third decade of the century solved one of the most difficult problems of housing in congested urban areas. In country districts and small towns, where such plants would not be economical, heating by elec-

tricity is now usual, in spite of the fact that it is apparently more expensive than the burning of fuel. This is because of the large saving in labor involved by employing electricity—and nowadays man-power is much more highly appreciated and conserved than it was half a century ago.

HYDRAULICS

Important advances have been made in the science of hydraulic engineering during the fifty years past. Late in 1917 one of America's most prominent hydraulic engineers in a private letter wrote as follows:

> The profession is somewhat handicapped by holding conventional views of water instead of a thorough knowledge of the internal workings and nature thereof. . . .
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> I have found that the hydraulics of the rivers themselves are very vaguely understood. The quantity of water flowing, the water surface elevation at many points corresponding to these volumes, and the length of time in which a change of stage is transmitted over forty or fifty miles of river concerned, are all rather vaguely comprehended; and in many cases text-book formulas instead of observations are used. I find an astounding amount of adventurous design in dams, evidenced by many failures. One of the causes of failure is the lack of understanding concerning the matter of the standing wave, in which water changes from a dynamic condition to one of more nearly static equilibrium. How to build a dam upon a glacial-drift foundation and utilize the full head available, thus conserving the water power, has not yet been clearly worked out.
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> Perhaps one of the chief faults in such cases is the lack of experimental data, preceding design and construction. In other words, we operate on the patient before we diagnose the case thoroughly. As the years go by we shall emphasize preliminary diagnosis in all engineering matters.

Some five years after the above was written, through the influence of our academy, the American government was persuaded into appointing a well-paid board of three of the country's most prominent hydraulic engineers (including, by the way, the writer of the letter just quoted) to study with a large force of assistants a number of hitherto unsolved questions in hydraulics. The work of that committee extended over a period of seven years; and the results of its investigations are of exceeding value. All the great hydraulic works of the world undertaken since the publication of its report have been based on its findings, and the saving of money resulting runs into the hundreds of millions of dollars.

IRRIGATION

During the early portion of the century, irrigation projects in the United States fell into disrepute, because many of them

had proved financial failures. This was due to the promoters having either dispensed with engineers' services altogether or else retained cheap ones who did not possess the necessary ability or experience. On that account it was almost impracticable fifty years ago to find an American banker who would finance an irrigation enterprise, no matter how promising the prospectus might show it to be. But as the country became more and more settled, there arose a demand for irrigable lands that could not be withstood, and irrigation once more came into its own. To-day there is left in our country comparatively little unwatered land that is capable of being irrigated at any reasonable expense. Our irrigated lands are the largest producing, the most reliable, and the highest priced of all the cultivated lands of the country, not excepting even the reclaimed lands of the Mississippi River delta.

Allied to irrigation is the watering of crops by the artificial precipitation of moisture. Early in the century certain credulous persons (as well as a few designing ones) made themselves ridiculous by vainly trying to cause rainfall in the arid districts of Kansas through the firing of cannon and the explosion of bombs. This fiasco made scientific men rather chary of even mentioning the subject of artificial rainfall; nevertheless Chiera Maclen Whask, C.E., in the early twenties proposed to some of his friends that they try to condense the fogs which blow from the Pacific Ocean over the tablelands of Southern California by spraying from above them liquid air carried on aeroplanes. Some experiments made thus by private subscription showed the scheme to be feasible; and it was then undertaken on a large scale by the Department of Public Works and proved to be a commercial success. The method has been followed in several districts along the Pacific coast of South America.

Levees

For about a century the building of levees in the Mississippi River delta was done piecemeal and in a haphazard and desultory manner, with the result that the said levees were being continually broken or overflowed, to the great detriment of the bottomlands for a considerable distance both above and below. The levees were lacking in both height and strength; and they were built in short lengths by different communities. Of course, under such conditions they were without system; and the protected (?) lands were annually in danger of being flooded. This prevented their proper settlement and development.

In the early twenties there was appointed a commission of engineers, first, to report upon the control of the Mississippi River and the reclamation and development of the adjoining lands, including the entire delta, and, second, to attend to the work of the said reclamation and development. It took a dozen years to complete the work, which was all done at the joint expense of the United States government and of the several states wherein the reclaimed lands were located. The products from these reclaimed lands are of a greatness and value staggering to the mind and almost incomprehensible. The soil is exceedingly rich; and most of it bears two crops per annum—in some places three. These lands truly form the garden-spot of the world, comparing in yielding capacity per acre quite favorably with the best of the irrigated lands of the West.

Lighting

Owing to the uniform distribution of power throughout the land, the problem of lighting has become a very simple one, and the farmer as well as the city-dweller now has all the light he needs for every purpose at a reasonable price. Being under government control, all lighting apparatus is kept in good repair and at a minimum of expense.

Materials of Engineering

Very few new materials for engineering work have come into use during the past half-century, but the old ones have been much improved, their scope has been greatly enlarged, and the cost of their production has been materially reduced. Numerous alloys of the metals have been manufactured and employed in the arts upon a commercial basis, including the before-mentioned high-alloy of steel for long-span bridges; the manufacture of hydraulic cement has been cheapened; and the use of timber has been reduced to a minimum. The heat-treatment of steel has increased its strength from two to three fold. Wrought iron has come back into use for many things in the manufacture of which it is superior to steel—for instance, tinned plate, metal employed near salt water, and cylinders for bridge-piers. The Bruntwasler process, developed after long delay in the early twenties, permitted the making of wrought iron directly from the ore, and thus kept the price down to a reasonable figure.

Mining

In this line of engineering the improvements have not been so marked as in most of the other lines. The dwindling supply

of gold has forced the adoption of more economic methods of extraction; and the increased demand for iron products has necessitated a cheapening of the mining of the ore as well as of the reduction of the metal therefrom. Most of the improvements in mining consist in the development of economic methods, and especially by working upon a large scale. The drainage of mines has received much attention; and it has been found practicable to operate deeper workings than formerly.

Power

Concerning this matter I have spoken at length before, and I, therefore, have not much more to say upon the subject, except to remark that a large elimination of physical labor has been effected by means of the development of machinery in many ways formerly thought impossible or uneconomical. There is an old saying to the effect that anything which can be manufactured by hand can be manufactured also by machinery; and it seems to have been nearly, if not quite, true.

Railroading

In railroading some fundamental improvements have been made in the last half-century, though not many in the standard-gauge system, which was used exclusively till about 1929, when the first wide-gauge trunk-line was built from Pittsburgh to the Great Lakes so as to carry long trains of ore cars weighing when loaded as much as 8,000 pounds per lineal foot. The gauge was made six and a half feet, and the rails were laid upon a concrete base, but not until after the embankments had come to a final settlement. Since then a number of other railroads have been built in that manner, but they are all used exclusively for carrying heavy freight between terminal points, and not for the ordinary distribution of light freight, which can be handled more economically by standard-gauge lines, especially since they have all been electrified. The last of the steam locomotives went out of commission some twelve years ago. They were found to be less economical in operation than electric locomotives, besides being exceedingly offensive to the traveling public because of their smoke. The building of very long tunnels, in order to reduce the heavy grades that used to exist on our transcontinental roads, rendered the employment of steam locomotives really dangerous to human life. The change in power began by the electrification of lines through such tunnels, and gradually extended so as to cover the rest of the line on which the tunnels were located. Finally, the electrically

operated lines proved to be so satisfactory that all lines were eventually electrified.

Considerable expensive railroad work has been done of late years by building belt lines around all large cities, not only to connect the various systems passing through them, but also to divert through-freight away from congested traffic-centers.

Another innovation in railroading was the adoption of the monorail system of transportation, evolved by Charles Whiting Baker and introduced by him in the early twenties, after many trials and tribulations. It is employed generally as a feeder to other railroads and to take the place of the electric railway in those localities where a more expensive type of construction is not warranted. At first the Baker system was operated solely by gasoline engines, but since it was proved to be a success it has sometimes been run by electricity.

Attention has been paid of late years to reducing the noise of operating railroads, and the attempt has proved quite successful.

Another important improvement in railroading has been the installment of automatic block signals, which now work to perfection.

The immense increase in the number of automobiles and the high speed at which they are driven have rendered imperative the separation of grade of streets and roads from railroad tracks, except in a few localities where the automobile traffic is light. It required federal control to establish this innovation; and in securing it the American Academy of Engineers took the leading part. The problem was essentially a financial one; and it was settled by dividing the expense of grade separation upon an equitable basis (which varied for different localities and different conditions) between the railroads, the federal government, and the municipal or state government.

In railroading, as in all other lines of technical activity, the substitution of machine labor for hand labor has effected great improvements—for instance, tie-tamping machines, ditching machines, rail-loaders and unloaders, and track-laying machines.

The old, slow process of surveying railway lines, taking topography and platting to scale on maps by using large forces of men has been very much simplified. Instruments of precision have been designed which traverse the sections of the country under investigation and accurately record on maps and profiles by fixed scales the same data that used to be obtained

by employing several field parties. As before mentioned, the aeroplane has been utilized to much advantage in railroad surveying.

The long-discussed question of government operation of railroads was settled by experience obtained during the Great War. It was finally decided thereafter that it would be better to continue to let the railroads operate as previously—but with certain restrictions, as well as certain liberties formerly denied them, rather than to leave them absolutely under government control. The restrictions of the Interstate Commerce Commission had proved to be so drastic and severe that the gross earnings decreased and the operating expenses increased to such an extent that the result was an annual deficit instead of an annual profit. Under continued conditions of this kind, the public refused to invest its savings in railroad securities; and, in consequence, railroad construction throughout the United States came to a standstill. Nor did the roads earn enough money even for up-keep of line and rolling stock; consequently the condition of the systems had deteriorated, wrecks had become common, and more or less general demoralization had ensued up to the end of 1917, when the government assumed control for the period of the war.

Pooling had been prohibited and treated as a crime; but the government itself soon learned that that method of operation was the only sane and economical one possible. Eventually, private ownership with government supervision, cooperation, and support was decided upon as the logical solution of the knotty problem. Experience has proved that it was a wise decision; for now when private investors refuse to lend their money for necessary improvements, the government lends what is needed; a legitimate pooling of interests of competing roads has been adopted; and the officials responsible for results have the opportunity of selecting those extensions which will be most beneficial to the wholesome growth and development of the country, and are in a position to prevent ill-advised duplication and multiplication of competing facilities, such as in times past placed an insupportable burden upon certain railroads and the communities that they served.

Reclamation

I have already referred at length to the reclamation of lands along the Mississippi River. Other minor rivers have been treated in the same manner, swamps have been drained, and sandy places have been covered with fertile soil. The

drainage of the immense swamps of Florida and of some of the other Gulf States has thrown open to settlement agricultural lands of untold value and productiveness.

The most elaborate and expensive reclamation project ever undertaken, or even contemplated, is that of New York Bay and the adjacent waters. It was conceived and advocated over fifty years ago by T. Kennard Thomson, a consulting engineer of New York City. After much discouragement, he finally succeeded in getting work started on his immense enterprise; but it has required fully four decades of hard work and untold millions of money to complete less than one half of the original scheme, notwithstanding the fact that, from the commercial standpoint, it has proved a success.

Reinforced-Concrete Construction

The use of reinforced concrete of late years has become far more general than was anticipated fifty years ago; for to-day it seems that almost any construction, large or small, excepting long-span bridges, can be built of that material. During war times, the reinforced-concrete vessel was perfected; and since then that material has usurped the place of steel, stone, brick, and timber in constructions of all kinds. When scientifically and honestly manufactured and used, it is a thoroughly reliable material; and the cost of its maintenance and repair, as compared with other types of construction, is truly a minimum.

River Improvement

In addition to the leveeing of the lower Mississippi River and the reclamation of the adjoining lands before mentioned, a scientific study of the problem of how best to improve the other navigable rivers of the United States was made at the expense of the government and under the management of our academy. A commission of seven expert engineers in various lines was appointed, with instructions to study certain of our great rivers and report upon how best to improve them so as to care for navigation, shore protection, water-supply, drainage, irrigation, and power. All these desiderata were to be duly weighed and evaluated, so as to determine in every case whether each item should be considered or ignored; and, if considered, to what extent. After the report upon each river was completed, the government (through our academy) decided what improvements were advisable for the immediate future, how they should be effected, what works could properly be relegated to the distant future, and what provision should be made for their ultimate

accomplishment. Then the improvement was regularly undertaken by the Department of Public Works, which body at times utilized its privilege of calling upon the academy for advice and counsel.

Another river improvement (of a temporary nature, however) that has been undertaken by the federal government of late years is the keeping open during the winter months, by means of ice-breakers, certain navigable waters, including among others the Mississippi up to St. Louis, the Hudson up to Albany, and the Ohio up to Pittsburgh.

The river improvements of our country are by no means completed—in fact one might say that they are merely started; for much yet remains to be done to help the regulation of the flow by building storage reservoirs near the headwaters and thus incidentally irrigating lands and developing power.

Roads

Fifty years ago the extravagance involved in the then-prevalent methods of road construction was simply a crime! From one end of the country to the other the people's money was squandered by incompetent, and often dishonest, county or township supervisors. Many of these men used to claim that they knew how to build roads as well as any engineer, consequently road-construction was hardly considered by our profession as coming within its realm of activity. A reaction began to set in about the end of the second decade, and a certain amount of roadwork was undertaken by some of the state governments; but it took many years to establish road-building upon its present satisfactory basis. To-day the great highways of the country are under federal control, and are handled by the Department of Public Works through its "Bureau of Roads"; and all other road-building comes under the jurisdiction of the various states, each state government having a special bureau therefor. As a result of this arrangement, our common roads are the most perfect of any in the world; and it is universally conceded that they pay for their first cost and upkeep many times over by reason of the fine facilities which they afford the farming community for delivering produce to the main arteries of transportation. Pleasure-travel by automobile, in consequence of our good roads, has become the most popular pastime of the nation; and the reaction therefrom upon the people through enlarging their horizon of acquaintance has been strikingly valuable.

SANITARY ENGINEERING

When one looks back upon the wasteful methods of sewage disposal which governed half a century ago, he can not but wonder how intelligent people—especially engineers—could countenance the discharge of unpurified sewage and waste products of manufactories into the streams and lakes, thus ruining them for water-supply and destroying the fish, besides wasting millions of tons of fertilizer so sadly needed by the farmers.

To-day it is not permitted to turn unpurified sewage into any water-course or lake; and the sources of our drinking water are guarded against pollution by the strictest kind of supervision. The result is that the people have pure water not only to drink but also to utilize in the arts; our lakes, rivers, and streams teem with fine fish, the supply of which is kept up by federal control; and the exhaustion of the country's soil, which was increasing at such an alarming rate a few decades ago, has ceased. Moreover, these are not the only important benefits secured through the adoption of common-sense methods of sewage disposal; because its effect on general health by the reduction almost to zero of certain diseases, which in times past were often veritable scourges, has proved to be a god-send to the community. I speak truly when I state that the consummation of this great economic reform is due primarily to the efforts of our academy, which brought a number of other technical societies, economic organizations and municipal governments into line, and thus induced Congress to pass and put into effect the necessary laws.

STEAMSHIPS

The improvements in ship-building of the last fifty years have been simply marvellous. Not only are the vessels far larger than they were formerly, but also they are equipped with every modern comfort and convenience for passengers and every facility for the economic handling of freight. Moreover, they are now made almost unsinkable; and the lanes of travel are so strictly followed that collisions of vessels at sea are almost unknown. The signaling between vessels and with the shore has been perfected; and various kinds of apparatus, working automatically, indicate the proximity and direction of other craft, icebergs and the land. No great increase in speed has been achieved, because the economic velocity of travel had already been attained half a century ago. It is true that we now can develop somewhat greater speeds, but it is not economical

to do so, except in special cases for the purpose of meeting unusual conditions.

STEEL BUILDINGS

In steel-building construction no fundamental advance has been achieved in the last half-century. It is true that we have in New York City an eighty-story building, but it has proved to be a white elephant for its owners. It has been found advisable in tall-building construction to study very carefully in each case all the conditions from the economic viewpoint, so as to determine what will be the best height to adopt when everything is given due consideration.

THE TELEGRAPH

Since the discovery of wireless telegraphy some sixty years ago, no fundamental improvement has been made in this branch of technics, unless it be the "teletypograph." By this apparatus there can be produced at any place in the United States or Canada, and also simultaneously at a great number of places, the contents of a typewritten page, the time required for transmission and reproduction being about one second. The message to be sent is first typed with a special ribbon upon a special kind of paper, and then this is run through a pair of rolls similar to those of the old-fashioned clothes-wringer. The distant reproductions are made on similar paper by means of a special ink.

THE TELEPHONE

The improvements in telephony of the past fifty years have been mainly in detail, excepting only that the wireless telephone has been perfected. It has not, however, put out of commission the ordinary telephone system in which wires are employed.

It has been found practicable to utilize a wire simultaneously for half a dozen messages without involving any interference; and the recording by phonograph of long-distance messages sent by wire is now not merely practicable, but is truly a paying business-venture. Some bold technical dreamers have lately been talking of recording in a similar manner telephone messages sent by wireless, but thus far nothing has really been accomplished through their experiments.

TUNNELING

In tunneling no great strides have been made in the fifty years past. Much longer tunnels have been constructed than were formerly built; but in subaqueous tunnel-work it has not

been found practicable to go much lower than one hundred feet below water, although in a few cases that depth has been exceeded by ten or twelve feet. We still have to depend upon compressed air to keep back the water. The freezing process did not prove to be commercially practicable for tunnels, although it has solved some difficult problems in the sinking of deep shafts. Important improvements have been made in the methods of tunnel-construction, and the unit prices of excavation therefor have been brought to very low figures.

Water Supply

No startling innovations in water supply have been made for many years, although a number of valuable improvements have been effected. In addition to the control of the pollution of watersheds previously mentioned, I might call attention to the use of Mayarí steel for pipes, which has increased their strength fully fifty per cent. and their cost in place only from twenty to twenty-five per cent. for the same weight of metal; to the greatly increased efficiency of pumping equipment; to the wonderfully dependable and durable coating for steel and iron, called "Anticorro"; and to the efficient and absolutely unobjectionable modern methods of purifying drinking water.

Conclusion

In drawing this rather lengthy address to a close, I should like to speculate as to what important improvements in engineering will be evolved in the next fifty years, so as, in a measure, to anticipate the retiring address of my distant successor in office when our academy celebrates the one hundredth anniversary of its establishment; but any attempt to do so would certainly prove futile. I must confess that I can not even prognosticate as to whether the progress in engineering during the next half-century will exceed or fall behind that of the one just ended; but this much I can very safely foretell: Whatever the said progress may be, a large proportion of it will be due to the initiative of our well-beloved society, The American Academy of Engineers.